EXHIBIT K

Mechanics of Materials

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the cable hangs vertically. Assume that the cable weighs 0.283 lb per cu in. and that the modulus of elasticity is 30,000,000 psi. *Ans.* 7.80 in.

1-28. A standpipe for water has a uniform diameter of 10 ft. If 6283.20 cu ft of water are pumped into the standpipe, how deep will the water be? Water weighs 62.4 lb per cu ft, and the modulus of elasticity of water is equal to 300,000 psi. Assume that the tank does not deform.

1-9. Definitions of stress terms. The definitions of two stress terms—elastic limit and proportional limit—have been given in sections 1-7 and 1-8. Definitions of other important stress terms follow.

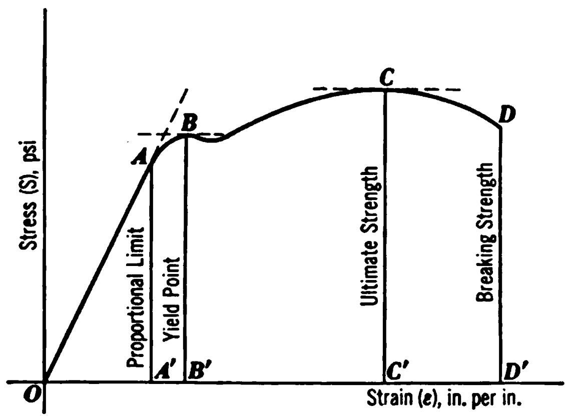

FIG. 1-27. Stress-strain diagram for low-carbon steel.

Suppose that a uniform bar of ductile metal, say low-carbon steel, is subjected to a gradually increasing tensile load. As the load increases, the elastic limit and the proportional limit are passed. Then a phenomenon occurs which the novice may mistake for failure because, at a certain stress, deformation continues without an increase of stress. This is not failure, however, since after a short interval of time an increase of stress is necessary to further deform the bar. As the loading is continued a second stress is reached where the deformation again continues without additional load until the specimen fractures. The former stress is called the *yield point*, and the latter, the *ultimate strength*. The yield point is therefore defined as the lowest stress at which a material continues to deform with no increase in stress provided that the stress can afterward be increased before the specimen fails. The ultimate strength is the greatest stress to which a material can be subjected.

Brittle materials, and some ductile metals such as nonferrous alloys, do not have a yield point. Because of this another stress term, *yield strength*, has come into use. Yield strength is defined as the stress that causes a specified permanent deformation. The permanent deformation commonly specified for ductile metals is 0.20 per cent of the gage length.

1–10. Stress-strain diagrams. The stress terms defined in sections 1–7, 1–8, and 1–9 can be represented graphically by means of a curve in a diagram called a *stress-strain diagram.* Unit deformations are customarily plotted as abscissas, and stresses as ordinates.

Figure 1–27 (a typical stress-strain diagram) represents the relation between stress and strain for a low-carbon-steel tensile specimen. At point A the curve departs from a straight line. Since the ordinates in the figure represent stress, the ordinate $A'A$ represents the proportional limit. For practical purposes $A'A$ also represents the elastic limit, because the values of the elastic limit and the proportional limit are commonly regarded as the same. At point B the tangent to the curve is horizontal and thus indicates continued deformation with no increase in stress. Therefore the ordinate $B'B$ represents the yield point. The ultimate strength is represented by $C'C$, the ordinate to the highest point of the curve. It

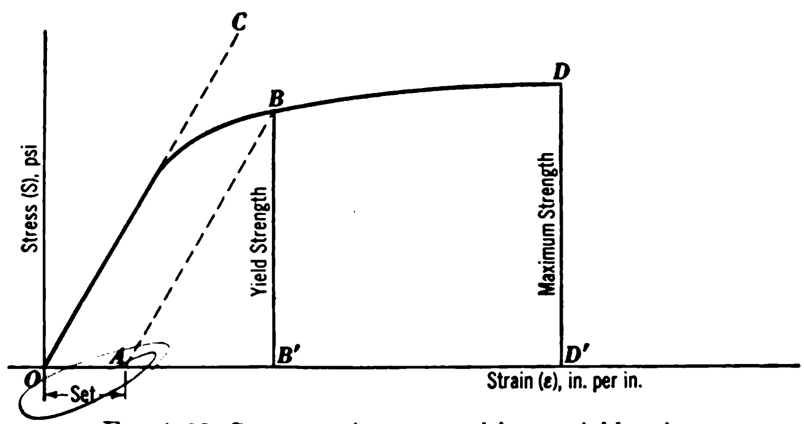

FIG. 1–28. Stress-strain curve with no yield point.

should be noted that all of the ordinates (stresses) are obtained by dividing the corresponding load upon the specimen by its original cross-sectional area. This is the customary procedure. Since the specimen is loaded in tension, the cross-sectional area decreases as the load increases. The decrease, however, is not large until the ultimate strength at point C is approached, after which a "necking down" (shown in Fig. 2–4) takes place. At the section where the specimen fractures, the cross-sectional area of the specimen is much smaller than its original area. Because of this the tensile stress existing at the fractured section is much larger than that represented by the ordinate $D'D$ shown in Fig. 1–27. For the part of the curve from point O to C the calculated stresses are more nearly equal to those existing in the specimen.

Some ductile metals, wrought aluminum alloys for example, have no yield point. Figure 1–28 shows the stress-strain diagram for such a metal.

The yield strength is represented by the ordinate $B'B$. To obtain the yield strength, a distance OA equal to the specified permanent deformation is laid off along ~~the strain-axis~~. Then from A a straight line AB is drawn parallel to the straight portion of the diagram to intersect the curve at B. It should be noted that the distance to point A is measured from the point of zero stress.

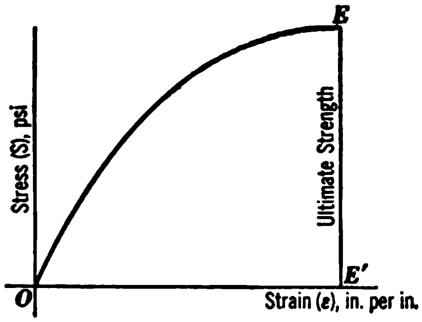

FIG. 1–29. Stress-strain diagram for brittle material.

The stress-strain diagram for a brittle material such as cast iron is shown in Fig. 1–29. In a brittle material the strain, compared with that of a ductile material, is small. To plot the curve of Fig. 1–29 the scale used on the horizontal axis, compared with that used in Figs. 1–27 and 1–28, must be magnified greatly. The stress-strain diagram for cast iron does not show a well-defined proportional limit. Usually the ultimate strength is the only stress value determined for a brittle material.

1–11. Components of stress upon oblique section of axially loaded prism. To obtain a clearer understanding of the behavior of a material under axial loading, a study will be made of the stress components perpendicular and parallel to any plane section inclined to the axis of an axially loaded prism. Figure 1–30a represents such a prism subjected to a pair of tensile axial forces P. Let mn be a plane inclined at any angle θ to the normal cross section separating the prism into two parts, and let the part to the left of mn be regarded as a free body. In accordance with the assumptions made in section 1–5, the resultant internal force, and likewise its components, are uniformly distributed over the section. Figure 1–30b shows the uniform distribution of the resultant stress, and Fig. 1–30c shows its normal and tangential components similarly distributed.

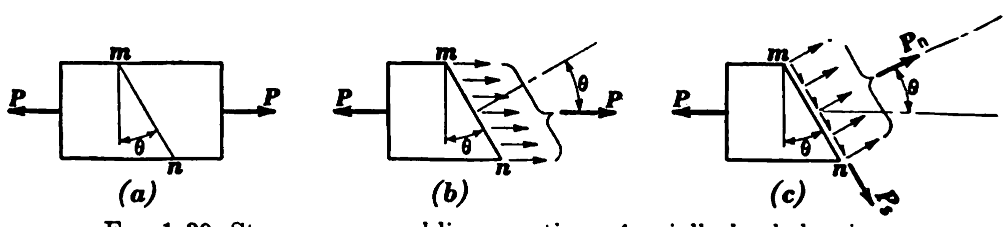

FIG. 1–30. Stresses upon oblique section of axially-loaded prism.

If the components of force perpendicular and parallel to the plane mn are designated by P_n and P_s, respectively, and their corresponding stresses by S_n and S_s, then